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Experimental Teleterminals—Hardware

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We have designed and built a series of experimental telephones that have facilities for both voice and data communication. The first of these has a 5-inch cathode ray tube character display and a small, full ASCII keyboard. Next to the display are twelve buttons whose labels are part of the display. The set is only a little larger than a standard telephone and can sit permanently on your desk without dominating it. It is a combination of an abbreviated computer terminal and a telephone and uses a microprocessor. Favorable experience with this first model led to several variations with larger displays and keyboards. We are still conducting experiments exploring the uses of these teleterminals.

I. INTRODUCTION

We have felt for some time now that a telephone set capable of providing integrated voice and data communications is desirable. A series of experiments to explore the possible uses of such a phone is under way. The key word here is "experiments"; we are not describing a development project and in fact one would not build a commercial product the way these experiments were built. The sets described here were internally referred to as GETSETS, an acronym for General-purpose Electronic Telephone SETS.

We have made a telephone with a microprocessor, a small keyboard, and a 5-inch cathode ray tube (CRT) display (see Fig. 1). The phone is small enough to sit permanently on your desk and measures about 9 inches wide, 10 inches deep, and 6 inches high. The keyboard has full American Standard Code for Information Interchange (ASCII) capability and the display has a capacity of 16 lines of 32 characters each. There are 12 buttons next to the display that can be labeled by writing text on the screen adjacent to the buttons. These buttons permit the user to perform any of a large number of complicated operations. The usual problem with having a large repertory of complicated operations

Fig. 1—Set 32.

is that it is difficult to remember the exact form of the commands if they are only used occasionally. It is much easier to recognize the command when it is presented as a button label, rather than having to recall it.

Even though the GETSET can function as a computer terminal, that is not our intent; the emphasis is on using the microprocessor to provide new and improved telephone functions. Modern electronic private branch exchanges, for example, have a processor powerful enough to provide abbreviated dialing, message forwarding, incoming party announcing, appointment calendar, and similar services. To access these functions, the telephone set needs a display and an alphanumeric keyboard. Since the set interacts with a host computer the keyboard needs full ASCII capability. All the ASCII characters, no matter how obscure, must be available. (It has been our experience that any apparently unneeded key, such as '$' in scientific computing, is given a critical function.) The display is a compromise between the desire for many characters and the limits of desk space.

In the future it will no doubt be possible to send mixed voice and data over a digital network; however, to experiment today we must use the existing analog network. In today's network there is a digital data path to the host computer and a separate voice line used for placing calls. The voice line uses the standard tone calling, dial tone, ringing, busy, etc.

II. MECHANICAL CONSTRUCTION

We started with a 10-button Multibutton Electronic Telephone (MET) set and removed the flat plate that contains the lamps, keys, and tone caller from the right side. This was replaced with the keyboard and a hood covering the CRT monitor. The phone network, speaker for the tone ringer, and switchhook are, as before, under the handset; however, it was necessary to repackage the network with the hybrid transformer shielded with mu-metal and rotated approximately 60 degrees about a vertical axis in order to eliminate magnetic pickup from the vertical oscillator coil and deflection yoke of the monitor.

All the electronics except for the power supply are in the set, under the keyboard and CRT tube. In so far as possible all parts are mounted to the sturdy grey plastic frame of the MET set. This allows the set to be operated with the top and bottom covers removed. There is a small "dog house" on the back of the set that covers the neck of the CRT tube, which is about 1½ inches too long.

III. FUNCTIONAL DESCRIPTION

Figure 2 shows a block diagram of the set. The keyboard chip, Standard Microsystems Corp. (SMC) KR2376-ST, converts key switch closures to 7-bit parallel ASCII codes, which are sent to the microprocessor. The buttons adjacent to the display are connected to this chip and are assigned control codes. The microprocessor, Intel 8748 with 8155 random access memory (RAM) and 8755A erasable programmable read only memory (EPROM), communicates with the host computer over a pair of serial data lines (typically 1200 baud) using a universal asynchronous receiver/transmitter (UART), Harris 6402-9.

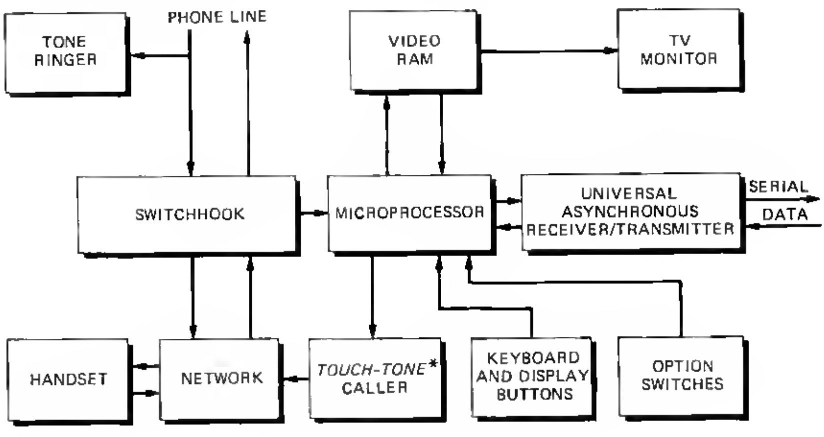

Fig. 2—Block diagram of SET32.

The microprocessor controls the display with a Matrox MTX 1632A Video RAM. To the microprocessor this looks like a 512 × 8-bit random access memory. Writing an ASCII code in location 000 causes the corresponding character to appear at the left end of the top line of the display. Location 001 comes next, and so on, with location 511 appearing at the right end of the bottom line. The Video RAM contains the character generator, refresh memory, and video and sync generators to drive the monitor.

The microprocessor also controls the tone caller, selecting the frequencies and closing a relay that mutes the phone transmitter, attenuates the receiver, and connects the caller through an isolation transformer to the network. The microprocessor can sense the state of the switchhook and make the clicker give audio feedback for the keyboard.

The monitor is a Ball Corp. TV-50 Data Display Monitor. We had to remake the printed circuit card in order to pack it into the set. This required mounting the components cordwood style and arranging the tall components to miss the neck of the CRT tube.

The tone ringer uses the American Microsystems Inc. (AMI) S2561 chip. It monitors the phone line for ringing current and converts it to tones driving the small standard speaker used in the MET set. It has a feature of ringing louder if the phone is not answered promptly. We have kept the rheostat from the MET set, which allows one to control the loudness of ringing.

Four of the seven option switches, which are mounted at the back of the set, control the baud rate, which can be set to any of the following speeds: 50, 75, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 2400, 4800, or 9600. The other switches are: local or on-line, half or full duplex, and RS 232 or current loop. There is also a reset push button that clears the screen and restarts the microprocessor program. Another control sets display brightness.

IV. POWER

The set draws about 0.7 ampere at +5 volts, about 0.8 ampere at +12 volts, and about 25 milliamperes at −12 volts for a total of about 13 watts. We have added slots in the rear top cover below the hood. These allow air flow, which keeps the set from overheating. The −12 volts is used only by the keyboard chip and the Electronic Industries Association (EIA) interface. The power at +12 volts is dependent on the display adjustment; making the raster wider, for instance, increases the current needed.

V. FIRMWARE

The program for the microprocessor is discussed in the companion paper.[1] Tables I and II of Ref. 1 summarize the command codes that the host uses to control the teleterminal.

VI. FURTHER DETAILS

6.1 The keyboard

The keyboard is based on a calculator keyboard. It has a molded silastic membrane with a hollow conical bump for each key. Inside each bump is a piece of conducting rubber; pressing on a button flattens the bump and pushes the conductive part against a printed circuit board where it electrically connects a pair of intermeshed fingers. The shape is such that the cone "snaps through" and gives a good feel. The keys are 12 mm on centers and the buttons are 5.5 by 6.5 mm. Making the keys relatively small allows even a very large finger to push a button without hitting the ones beside it. The buttons are too close together to permit touch-typing; it is really a two-finger keyboard.

The key array is 5 keys high and 12 wide with the space "bar" taking up two key positions. The top row is used for placing calls. In addition to the ten digits, the leftmost key has "*" and the rightmost is labeled with a modified "square" as well as "underline." (In ASCII use, the key produces "underline" in both upper and lower case.)

The clicker, which gives acoustic feedback, is a Western Electric MA5A relay with the contact stack removed. It is mounted so the armature strikes the frame to make the click. The microprocessor drives it with a 14-millisecond pulse.

The six buttons on each side of the display are also mounted 12 mm on centers. The vertical centering and height of the display are adjusted so that the buttons line up with the first line and every third line after that.

6.2 CRT monitor

Since telephones are used in many different ambient light situations, it is desirable to improve the contrast of the screen. We have tried tubes with dark-colored phosphor and also bonded, neutral-grey filter faceplates. Both of these decrease the ambient light reflected from the screen. Current sets have the dark-colored phosphor and an etched front surface on the faceplate.

6.3 Microprocessor

We started with just an Intel 8748; however, it soon became clear that it was not fast enough to keep up with incoming display data at 1200 baud. We therefore added the 8155 RAM, which has 256 bytes, as a buffer. This is enough for half of a solid screenful and seems to be adequate. It also gave us some more input/output (I/O) ports. Next we ran out of program space so we added the 8755A EPROM. This added 2K bytes, about half of which are used, and more I/O ports, which we are also using.

VII. STATUS AND FURTHER EXPERIMENTS

We have built about three dozen of these sets. Approximately half of them are being used by members of our center in an experiment to test their use by a community of users and to develop new telephone functions. Others are mainly used for demonstrating the concept of a teleterminal. To test various proposed improvements, we have built three "breadboard" models. These models contain only keyboards and displays. We connect them to a Cromemco Z80 microprocessor. This has the advantage of allowing us to program in C language rather than assembly language.

Figure 3 shows the color set. It has the same keyboard as the original set. The display is a 5-inch color tube from a Sony color TV monitor. Since the color tube is larger than the black and white one, this makes the case deeper and boxier than the first set.

Figure 4 shows an intermediate-size set. The display is the same height but 1-1/2 inches wider than the first set. It has 16 lines of 64 characters each. We have added nine new buttons across the bottom of the screen that can be labeled with the last line of the display. We have used the same membrane keys but spread them sideways to take up the extra 1-1/2 inches. You can place your fingers on adjacent keys (with no extra space). It may be possible to touch-type on this keyboard.

Figure 5 shows the largest of the three models. It has almost a full-

Fig. 3—The color set.

Fig. 4—Set 64.

Fig. 5—Set 80.

sized keyboard. The display has 24 lines of 80 characters, the same as most computer terminals. It is a low-profile tube so the display is about 3-1/2 inches high and 7-1/4 wide; however, the definition is good and it is easy to read. The characters are about the same size as

ordinary typewriter output. There are eight buttons on each side and nine across the bottom of the display. With the addition of a speakerphone and a telephone interface that imitates a six-button keyset, this set is being used in the Executive Planning Information and Communication (EPIC) trial.[2]

VIII. CONCLUSION

This paper has described a series of experimental teleterminals. These have been used to provide a new, computer-enhanced telephone and other services. Probably no one teleterminal suits all users' needs. Rather there should be a variety available, so that users can choose the keyboard display and other features that are most suited to their needs.

IX. ACKNOWLEDGMENTS

Many people have made contributions to this project. We owe inspiration to H. S. McDonald for his notion of a "Superphone." We are indebted to D. L. Bayer for guidance and help in programming the microprocessor. R. A. Payne built the cases for the color set and the intermediate-size set; W. Kaminski designed the keyboards and displays for all the breadboard sets, and J. M. Gaughran contributed the layout for more than a dozen different printed circuit cards. He also expedited their production, often under a tight schedule. We particularly want to thank R. A. Thompson for the programs in the host computer, which make the teleterminals do something useful.

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